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Research paper

Geomorphic indices and relative tectonic uplift in the Guerrero sector of the Mexican forearc

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ABSTRACT

Tectonically active areas, such as forearc regions, commonly show contrasting relief, differential tectonic uplift, variations in erosion rates, in river incision, and in channel gradient produced by ongoing tectonic deformation. Thus, information on the tectonic activity of a defined area could be derived via landscape analysis. This study uses topography and geomorphic indices to extract signals of ongoing tectonic deformation along the Mexican subduction forearc within the Guerrero sector. For this purpose, we use field data, topographical data, knickpoints, the ratio of volume to area (R_{VA}), the stream-length gradient index (SL), and the normalized channel steepness index (k_{sn}).

The results of the applied landscape analysis reveal considerable variations in relief, topography and geomorphic indices values along the Guerrero sector of the Mexican subduction zone. We argue that the reported differences are indicative of tectonic deformation and of variations in relative tectonic uplift along the studied forearc. A significant drop from central and eastern parts of the study area towards the west in values of R_{VA} (from ~500 to ~300), SL (from ~500 to ca. 400), maximum SL (from ~1500–2500 to ~1000) and k_{sn} (from ~150 to ~100) denotes a decrease in relative tectonic uplift in the same direction. We suggest that applied geomorphic indices values and forearc topography are independent of climate and lithology. Actual mechanisms responsible for the observed variations and inferred changes in relative forearc tectonic uplift call for further studies that explain the physical processes that control the forearc along strike uplift variations and that determine the rates of uplift. The proposed methodology and results obtained through this study could prove useful to scientists who study the geomorphology of forearc regions and active subduction zones.

1. Introduction

In active subduction zones, ongoing tectonic deformation is the main factor that is contributing to contrasting relief, differential tectonic uplift, variations in erosion rates, in river incision, and in channel gradients. Therefore, landscape analyses of such areas and studies of drainage networks, in particular, provide insights into current tectonic processes and their activities. Attempts to quantify tectonic deformation from landscape analyses have been performed for decades (e.g., Bull and McFadden, 1977; Rockwell et al., 1985; Merritts and Vincent, 1989; Burbank, 1992; Burbank and Anderson, 2001; Keller and Pinter, 2002; Wobus et al., 2006, 2010; Kirby and Whipple, 2012). Since the beginning of the twentieth century, several geomorphic indices have been proposed to estimate the extent of current tectonic processes. The rapid development of GIS techniques and the constant advancement in digital elevation model (DEM) quality and access provide powerful and efficient tools to compute, calculate and analyze geomorphic indices across areas of various environments and scales (e.g., Keller et al., 1982; Ramírez-Herrera, 1998; Kirby et al., 2003; Gürbüz and Gürer, 2008; Arrowsmith and Zielke, 2009; Gasparini and Whipple, 2014). However, studies that use geomorphic indices to explore the relative activity of tectonic processes in the forearc regions of active subduction zones are limited and/or use only one or two indices

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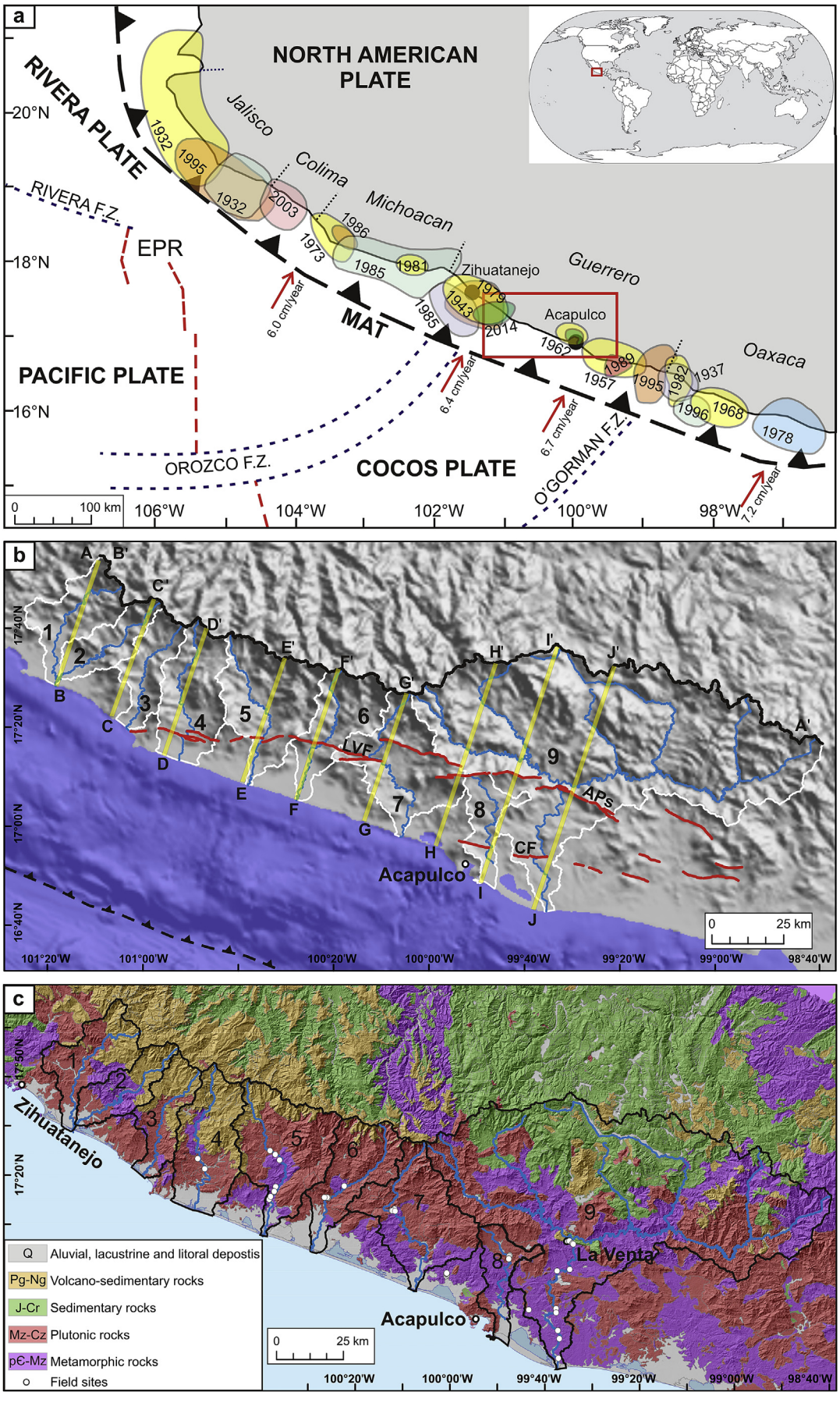
a
NORTH AMERICAN PLATE
RIVERA PLATE
PACIFIC PLATE
COCOS PLATE
RIVERA F.Z.
EPR
OROZCO F.Z.
MAT
O'GORMAN F.Z.
Jalisco
Colima
Michoacan
Guerrero
Oaxaca
Zihuatanejo
Acapulco
6.0 cm/year
6.4 cm/year
6.7 cm/year
7.2 cm/year
1932
1995
2003
1986
1973
1985
1981
1979
1943
2014
1963
1989
1957
1995
1982
1937
1996
1968
1978
20°N
18°N
16°N
106°W
104°W
102°W
100°W
98°W
0 100 km
b
A
B'
C'
D'
E'
F'
G'
H'
I'
J'
A'
B
C
D
E
F
G
H
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J
1
2
3
4
5
6
7
8
9
LVF
APs
CF
Acapulco
17°40'N
17°20'N
17°00'N
16°40'N
101°20'W
101°00'W
100°20'W
100°00'W
99°40'W
99°20'W
99°00'W
98°40'W
0 25 km
c
Zihuatanejo
La Venta
Acapulco
17°30'N
17°20'N
Q Aluvial, lacustrine and litoral depostis
Pg-Ng Volcano-sedimentary rocks
J-Cr Sedimentary rocks
Mz-Cz Plutonic rocks
pЄ-Mz Metamorphic rocks
Field sites
0 25 km
100°20'W
100°00'W
99°40'W
99°20'W
99°00'W
98°40'W